

DOCUMENT RESUME

ED 128 205

SE 021 286

AUTHOR Schlenker, Richard M.
TITLE Investigations in Marine Chemistry: Tide Pool Ecology.
PUB DATE [76]
NOTE 13p.
EDRS PRICE MF-\$0.83 HC-\$1.67 Plus Postage.
DESCRIPTORS *Chemistry; *Ecology; Elementary School Science; Elementary Secondary Education; *Field Trips; Marine Biology; Mathematics; *Science Activities; Science Education; Secondary School Science
IDENTIFIERS Tide Pools

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Investigations in Marine Chemistry: Tide

Pool Ecology

by

Richard M. Schlenker

U.S. DEPARTMENT OF HEALTH,
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Abstract

Students investigate the salinity of tide pools at different levels in the intertidal zone.

Data ~~are~~^{are} analyzed collectively. Students graph and discuss data. Included are suggestions for evaluation and further study.

Introduction

Tide pool ecology is an important and integral segment of the greater realm of intertidal ecology. What happens in a tidal pool once the receding tide has recessed to a point where water exchanges between the large water mass and the pool can no longer take place? The answer to this question provides important insights concerning a given organism's ability to survive fluctuating parameters. For example, once trapped in one of these pools, the degree to which an organism is euryhaline may determine the organism's survival until the pool is relieved by the advancing flood tide.

If we operate on the premise that varying salinity is an important factor governing life in a tide pool, then it becomes an important area of concern for the student of intertidal ecology.

In order for salinity to increase after the tide recedes, evaporation must occur. Since evaporation requires an energy input, salinity should increase at a more rapid rate as the ambient surrounding temperature increases. Thus, salinity in a given pool should increase to a higher level at a faster rate on a hot sunny day than on a cool overcast day. A salinity increase, however, only sets one end of the range.

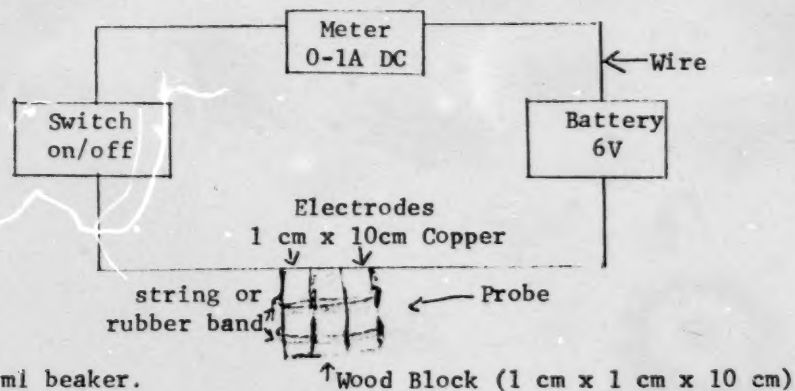
Salinity may also decrease following the passage of the ebb tide. For example, once a pool becomes isolated and can no longer communicate with the larger water mass, it may be diluted by rainfall. Quite obviously, the rate and amount of dilution will depend upon the amount of rainfall per unit time and the length of time during which the rain falls. While the amount of dilution will vary with each given situation, it is possible to state categorically that this agent will set the extreme lower limit of salinity.

One heretofore unmentioned agent may cause a salinity increase during cold weather. If the surrounding temperature is less than about -2°C , the surface water in pool will start to freeze as soon as the ebb tide loses communication with the pool. Freezing will continue until the pool is again covered by the flood tide. When freezing takes place, only the water freezes while minerals and salts become more concentrated in the unfrozen portion of the pool.

In this unit the student investigates salinity changes in a tidal pool as the length of isolation time increases.

Materials

1. A simple conductivity meter. The following design will work nicely. Details concerning theory, design and calibration can be found by consulting Schlenker (1976a, 1976b)



2. One 250 ml beaker.
3. One thermometer, graduated in $^{\circ}\text{C}$.
4. Paper and pencil.
5. Graph paper.
6. Straight edge.
7. One watch or other time keeping device.
8. Several tide charts (available from most ship chandlers)

Objectives

1. To investigate tidal pool salinities.
2. To compare tidal pool salinities with ambient surrounding temperature and time, following initial pool isolation from the greater water mass.

Goals

As a result of participation in this unit the student will be able to:

1. Measure the conductivity of a given quantity of tide pool water and determine its salinity.
2. Plot tidal pool salinity vs. time, tidal pool salinity vs. temperature.
3. Predict, in future situations, what salinity conditions probably exist in a tidal pool.
4. Predict the degree to which an organism is euryhaline, based upon environmental parameters.

Procedures

1. The instructor locates suitable field trip sites.

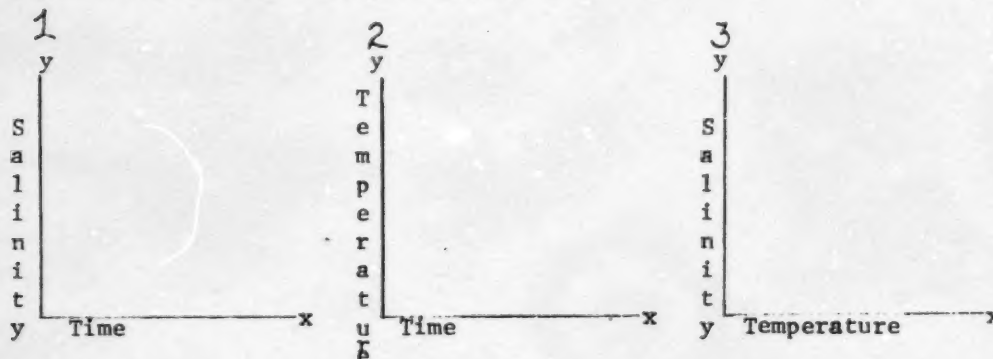
Field site selection requires several considerations. Depending upon what types of results are required for the total group effort will determine the type of site which is chosen. For example, you may desire to split the group and study pools at several different levels within the intertidal zone. If you are comparing the results obtained by two groups, you might want your pools to be of similar volume and surface area. Or you may decide that you also wish to study the heat capacity of water and how salinity is related to the total pool volume. Site selection also requires a consideration of safety, see Nutting, Zottole and Gustafson (1971).

2. The instructor obtains tide chart and decides what day would best be suited for the exercise. This exercise, of necessity, requires a large time block. For optimum results, the students should arrive at the intertidal area at or about the time when the ebb tide is beginning to isolate various tidal pools.
3. A class discussion is held several days prior to the trip. Safety and proper clothing e.g. grip type shoe soles should be discussed as well as what is to be accomplished while at the site.
 - A. There will be ample time to study the physical and biological parameters. These should be discussed and a list of questions which will be answered should be generated.
 - B. Field notes and field notebooks should be discussed. Remember the only truly reliable field notes are those taken in the field.
 - C. Methods of taking salinity measurements should be discussed. All measurements should be accomplished with as much scientific control as possible. A time interval should be chosen for salinity readings. This interval (for example $\frac{1}{2}$ hour between readings) should be held constant. When measuring salinity, the amount of water measured in each container should be held constant. One method is to fill the beaker with 200 ml of sea water each time a reading is taken. Probe immersion depth should also be held constant. (Schlenker, 1976b).
 - D. Discuss the collection of temperature data. These data should be collected at the same time the salinity readings are taken. Interesting relationships might be found by taking the environmental temperature as close to the pool as possible and at the same time, measuring the water temperature.

4. Collecting containers should be assembled for use in collecting materials at the shore.
5. The students should each read and become familiar with a tide chart.
6. Based upon the tide chart, the students as a group should decide upon the best day for the field work (this must be accomplished within the context of the class meeting schedule).
7. The students decide upon an experimental design which best suits their goals. For example, as previously mentioned, the group may decide to sample several pools at different levels within the intertidal zone.
8. The group should be divided according to experimental design so that there will be no wasted effort.
9. At the data collection site--the previously designed schedule is carried out. Final data analysis and discussions will take place after return to school.
10. Following the trip:
 - A. Hold a group discussion to consider methods of data analysis.
Since the total data collection was a group effort, a group effort will be required in order to analyze the data.
 - B. A group coordinator should be elected by the group.
 - C. Each subgroup should evaluate the data collected from the tidal pool in which they worked. This comparison can be made using a graph. Let's assume for discussion purposes that the trip was conducted on a hot sunny day. Also, let us assume that time 0 is the time of the first salinity reading and also the time when the pool was fully isolated from the larger water mass. At least three comparisons can be made:

1. salinity vs. time
2. surface water temperature vs. time
3. surface water temperature vs. salinity.

These comparisons should be accomplished mathematically using "x" and "y" coordinates. In the first comparison, salinity depends upon time, in the second, temperature depends upon time and in the third, salinity may depend upon temperature. Remember that the dependent variable is graphed along the "y" axis while the independent variable is graphed along the "x" axis.



A glance at the student's field notes reveals groups of ordered pairs of data. For example,

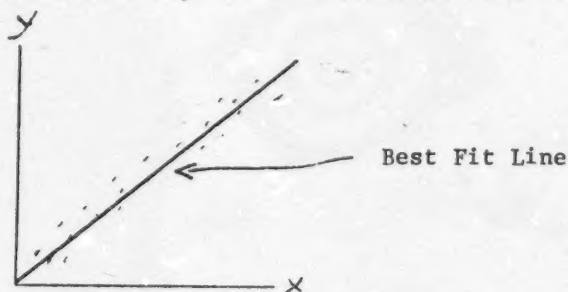
Time (in mins.)	0	30	60	90	120	150	180	...
Salinity	35	?	?	?	?	?	?	...

these ordered pairs should be plotted on graphs constructed on graph paper. Using the first pair shown above, (0, 35) as an example 0 is the "x" coordinate since it is the independent variable and 35 is the "y" coordinate and dependent variable. All data should be graphed in this manner. When graphed, a group's data

will probably appear as follows:

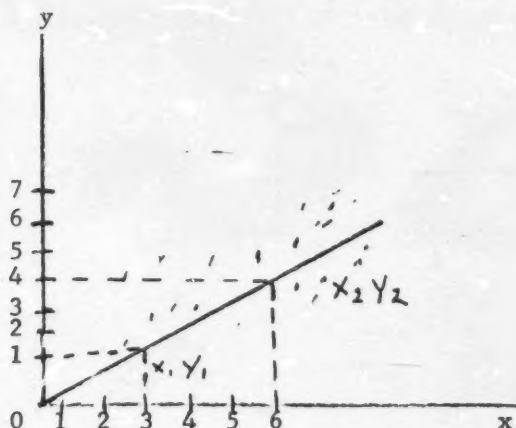


The group should now draw a best fit line or a line which seems to run through the center of all the data. There is a mathematical method by which this line can be located but the mathematics at this point would only serve to frustrate the student.



This line has the formula $y = mx + b$, where m = the slope or the rise/run and the run is the distance along the "x"-axis and the rise is the distance along the "y" axis. This ratio indicates the number of units of rise along the "y" axis for every unit of run along the "x" axis. You will recall, for example, that 3 can be written in this form or it can be written as $\frac{3}{1}$. $3x$ in the formula then would mean that every one unit along the "x" axis that the line traveled, it traveled 3 units along the "y" axis. The "b" represents the "y" intercept or the point at which if the best fit line is extended, it will intercept the "y" axis. Once the best fit line has been drawn, it is possible to say at any given moment after time, $T = 0$, what the salinity was. In order that

the students are able to take full advantage of the data which they have collected, an equation for the best fit line should be derived from the formula, $y = mx + b$. To accomplish this task, two points on the line are required; these may be chosen arbitrarily. For example,



$$\text{Slope} = m = \frac{\text{rise}}{\text{run}} = \frac{(x_2 - x_1)}{(y_2 - y_1)} = \frac{(4 - 1)}{(6 - 4)} = \frac{3}{2}$$

The value of "b" may be found either by extending the best fit line to intercept the "y" axis or mathematically. After the slope has been determined, it may be substituted in the formula

$$y = 3x + b$$

Since we already have our best fit line, we'll put it to work.

First of all, pick an "x" value--say 4, and then measure horizontally to the "y" axis; what's the "y" value? It should be 7.

Substitute the values of "x" and "y" in the formula and solve for b.

$$y = mx + b$$

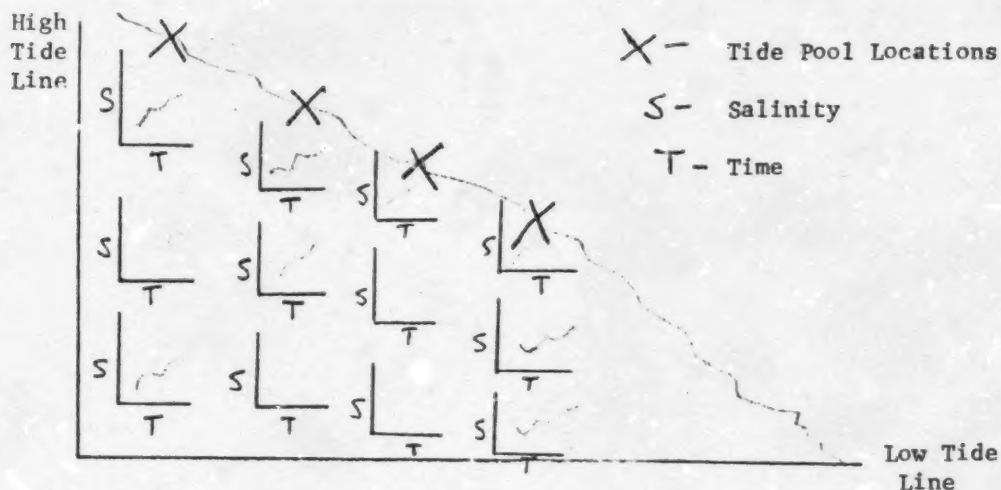
$$7 = \frac{3}{2} \cdot 4 + b$$

$$b = 7 - 6$$

It follows that the equation for the best fit line in this data plot is:

$$y = \frac{3}{2}x + 1$$

- D. The groups should compare data. One possible way to show the findings of all groups would be via a wall chart. The wall chart could show the intertidal slope and the locations of pools. Below each pool, each group could post the graphs of their findings.



- E. Conduct a group discussion. One important subject to be discussed is a comparison of the equations of the lines.
1. discuss the significance of identical formulas.
 2. discuss the significance of identical slopes but different "y" intercepts.

Evaluation

1. Give the students data concerning weather conditions, pool location within the intertidal zone and length of the tide, salinity of the greater water mass and the range of salinity tolerance of some tide pool organisms.

Have the students design an investigation to ascertain the salinity variation in the pool and discuss the possibilities of the given organisms survival in that pool over an extended period of time.

Suggestions for Further Study

1. Rerun the field trip on a rainy day.
2. Rerun the field trip in the winter during a period when the prevailing temperatures are 10° - 20° below freezing.

References

1. Nutting, William B., Zottoli, Robert and Gustafson, Alton H., Tide Pool Transect. American Biology Teacher, 33(5):282-285; May 1971.
2. Schlenker, Richard M., Investigations in Marine Chemistry: Salinity I. U. S. Office of Education, ERIC, in press, 1976a
3. Schlenker, Richard M., Investigations in Marine Chemistry: Salinity II. U. S. Office of Education, ERIC, in press, 1976b.